Phantom Evaluation of Reconstruction Advancements with Finer Image Grid for Myocardial Perfusion SPECT

Jinghan Ye, Xiyun Song, Angela J. Da Silva and Horace H. Hines
Philips Healthcare, San Jose, CA

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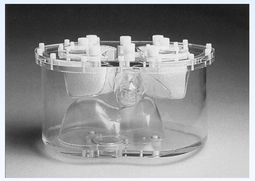
Introduction

Recent advancements in SPECT reconstruction including attenuation correction (AC), scatter correction (SC), resolution recovery (RR), and noise reduction (NR) improve image quality and benefit myocardial perfusion imaging. Despite these advancements, standard acquisition and reconstruction protocols with a ~6-mm pixel size are routinely used clinically. In this study we examine the potential of combining reconstruction advancements with finer pixel size.

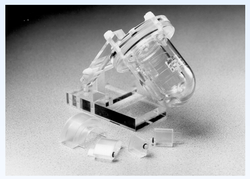
Methods and Materials

Phantom

- Data Spectrum Anthropomorphic Torso phantom (Figure 1)
- Cardiac insert with uniform 10-mm thick myocardial wall chamber (Figure 2)
- Two defect inserts: 20x20 mm^2 each, 5-mm and 10-mm thick
- Normal: without defect inserts
- Abnormal: with defect inserts in the myocardial wall chamber
- The phantom was filled with Tc-99m: 0.4 mCi, 1.5 mCi, and 2.5 mCi in myocardial wall chamber, liver, and background, respectively



1. Anthropomorphic phantom with cardiac insert in place



2. Cardiac and defect inserts

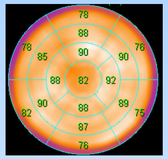
Data Acquisition

- Phantom scanned on Philips BrightView XCT SPECT/CT camera
  - CT: 1-mm isotropic voxel size
  - SPECT: Concurrent acquisition of 6.4-mm and 3.2-mm pixel size combined with 5- and 20-seconds/frame (s/f), all with 64 frames

Image Reconstructions

- FBP: Filtered backprojection reconstruction without AC, SC, or RR, with low-pass filter for noise control using 6.4-mm projection data
- ASR: Iterative ordered-subsets expectation maximization (OSEM) reconstruction with AC, SC, RR, and NR using 3.2-mm projection data

3. Line profiles through myocardial walls for wall thickness measurement



4. Polar plot of myocardium and 17 regions

Image Comparison

- Visual comparison
- Myocardial wall thickness accuracy

  Wall thickness = FWHM of line profiles through the walls

  Average at 45 locations on the walls (Figure 3)
- Myocardial wall thickness uniformity

$$\text{Uniformity} = (1 - t_{std}/t_{mean})*100\%$$

  - t_{mean}: mean of thickness measurements
  - t_{std}: standard deviation of thickness measurements
- Myocardial count non-uniformity

$$\text{Non-uniformity} = (c_{std}/c_{mean})*100\%$$

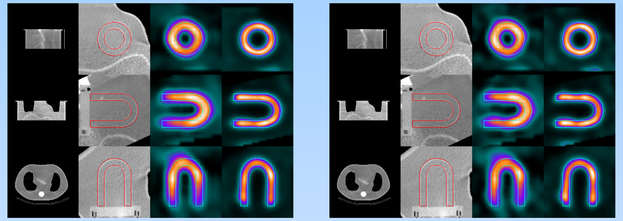
  - c_{mean}: mean count values extracted from 17 regions (Figure 4) of the myocardium in polar display using AutoQuant® software
  - c_{std}: standard deviation of the count values
- Defect contrast

$$\text{Contrast} = (c_{bkg} - c_{def})/c_{bkg}*100\%$$

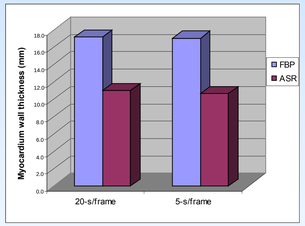
  - c_{def}: average counts in defect area
  - c_{bkg}: average counts in surrounding area

Results and Discussions

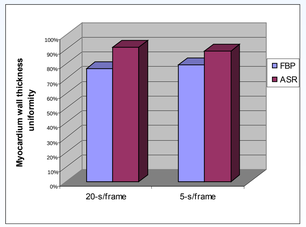
Normal Phantom



5. Normal phantom images reconstructed from normal (left) and low (right) count projection data. CT images of the anthropomorphic phantom and the reoriented cardiac images are in the left two columns; FBP reconstruction from 6.4-mm pixel projection, and ASR reconstruction from 3.2-mm pixel projection are in the two right columns. The boundaries of the myocardial wall are outlined.

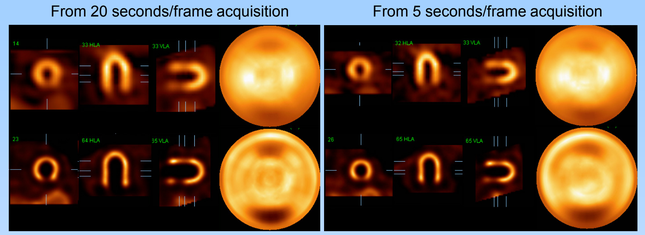


6. Myocardial wall thickness accuracy measured from reconstructed images from 20-s/f and 5-s/f projection data. The true wall thickness is 10 mm.

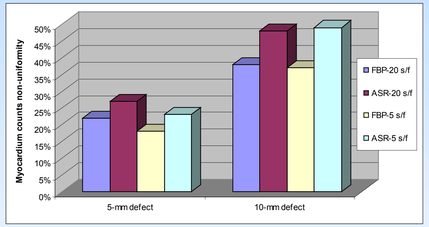


7. Myocardial wall thickness uniformity measured from reconstructed images from 20-s/f and 5-s/f projection data. The ideal uniformity is 100%.

Abnormal Phantom



8. Images reconstructed from cardiac phantom with defect inserts using normal (left) and low (right) count projection data. FBP reconstruction (top row) uses 6.4-mm pixel size and ASR (bottom row) uses 3.2-mm pixel size. The defect near the basal inferior wall is 10-mm thick; the one near the mid-anterior wall is 5-mm thick.



9. Defect contrast measured from images in Figure 8. The ideal contrast for the 5-mm thick defect is 50%; that for the 10-mm thick defect is 100%.

Conclusion

The combination of reconstruction advancements and a finer pixel size produces more accurate and uniform myocardial wall thickness and more uniform counts in the normal phantom as compared to FBP with standard pixel size. The former also produces higher defect contrast. Additionally, the superiority of the first combination still holds true with only 1/4 of measured counts.

Disclosures

All authors are employed by Philips Healthcare.

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